'Aluminum foil makes a good EMI gasket in a pinch, but it's tough to market a product packaged up like a Hershey's Kiss.'

EMI gaskets *catch the wave*

Once considered an 'inelegant solution,' this venerable technology helps engineers keep EMI out of mischief

Karen Auguston Field, Managing Editor

As if design engineers aren't busy enough, many of them now have to contend with the new EMC Directive. Generally considered one of the most complicated of all European Union regulations, it not only regulates the amount of EMI that certain electronic products can emit, but it also has the dubious honor of being the first regulation ever to incorporate an EMI immunity requirement.

So what's the big deal? Bottom line: about 30 dB of additional shielding. Not exactly small potatoes, especially when you consider that decibels are logarithms of noise levels.

In most applications, however, the main concern is not over the shielding per se, but rather in figuring out how to establish a completely conductive envelope around the electronics. Ironically, the technology of choice today for doing this was once considered by many engineers to be an inelegant solution.

"Engineers like to argue that gaskets are a mechanical solution to an electrical problem, and that it is always preferable to improve EMI immunity at the board level through device filters and such, even though these techniques limit the operational characteristics of the system," says Ron Brewer, VP of EMC technical services for Instrument Specialities, a leading supplier of EMI gaskets.

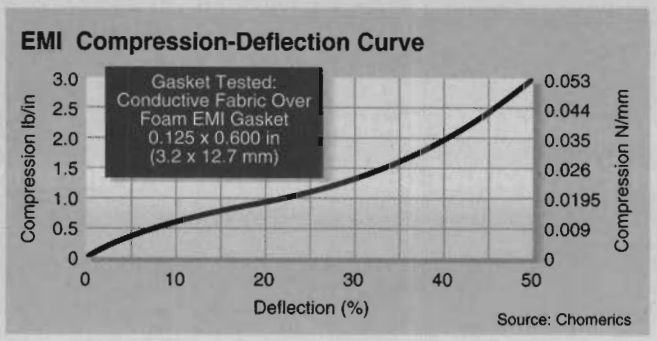
A 30-year veteran of the EMC industry, Brewer likes to point out just how much times have changed. "Many engineers today are finding out that the only way they can protect a system without slowing down that high-speed processor inside is by shielding at the enclosure level," he says. "A whole new generation has discovered EMI gasket technology, and they aren't a bit snobbish about using it."

Short-circuit city. Simply put, EMI shielding works by reflecting and absorbing mischief-making electromagnetic waves (see sidebar). Although strictly speaking any metal (or metal-plated plastic) enclosure *is* a shield, it is not a perfect shield unless it's a solid box with the door welded shut. Stray voltages and currents can sneak in through doors, openings for cables, inspection panels, in fact, virtually anywhere there is a break in the electrical circuit formed by the walls of the enclosure. A general rule of

thumb for adequate shielding is no openings of more than 1/10 to 1/20 the wavelength of the highest frequency.

The trick is to seal up any offending gaps with a conductive material. At this point, the astute engineer may be thinking about the possibilities of aluminum foil. But although a staple of labs everywhere, it does not possess the requisite mechanical strength. And it's going to be tough to convince the marketing department to pitch a product packaged up like a Hershey's Kiss.

Myriad choices. Fortunately, better, more-practical solutions are available. Initially developed for the military and telecommunications industry but now in wide general use, EMI gaskets come in six basic flavors: metal fingerstock; conductive elastomers; form-in-place elastomers; knitted wire mesh; knitted conductive yarn, conductive fabric, or metal foil over foam; and wire mesh combined with elastomer. Each alternative offers relatively good tradeoffs in terms of shielding effectiveness, mechanical performance, and cost (see chart at right).



When evaluating EMI gaskets, always ask to see the compression-deflection curves like the one shown here, particularly if somebody tells you that the gasket has a low closure force. In fact, compression-deflection is one of the biggest mechanical issues associated with gaskets. To function properly, all EMI gaskets require some degree of compressive force, which squishes down (or deflects) the gasket proportionally. One major challenge for engineers is to design a gasket that is stiff enough to resist crushing when a force is supplied, yet at the same time is soft enough to deflect enough to maintain proper contact with mating flanges. As a point of reference when designing-in gaskets, a typical human (i.e., not Superman) can comfortably apply about 50 lbs of force.

The ever-popular metal fingerstock consists of rows of resilient, spring fingers typically made of beryllium copper (it has the highest conductivity of any metal that can be made into a spring), but also available in stainless steel. Of course there are tradeoffs involved, but metal fingerstock offers the best shielding effectiveness over a wide range of frequencies.

One unique characteristic of fingerstock is its ability to work in shear applications. "If you mount fingerstock sideways in a door, for example, every time that door closes, it is actually wiping across the fingers and pushing them in. That's how they're designed to work," says Joseph Butler, marketing manager for the Chomerics Division of Parker Hannifin Corp. (Woburn, MA), another leading supplier of EMI gaskets. "Continuous flexing like that of any other type of gasket will just rip it apart after awhile."

The most versatile of all gasket types are the molded conductive elastomers, which come in a seemingly endless variety of shapes and formulations. Typically the weirder the shape of the gasket, says Butler, the lower the compression force required, which is one of the biggest mechanical issues associated with gaskets (see curve, above).

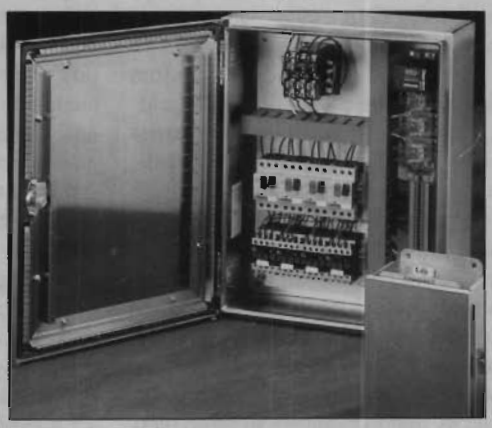
These silicone- or fluorosilicone-based elastomers get their conductive properties through filler particulates. A co-extruded strip of a conductive and non-conductive elastomer is available for applications that require both EMI and environmental protection.

"Elastomers filled with nickel-plated graphite particles are a hot-selling item today," says Butler, due to their excellent shielding performance and good resistance to galvanic corrosion. A particular concern with outdoor enclosures, corrosion occurs when salt fog or air permeates the enclosure—and it's not pretty. "If you don't use a gasket that has been designed to negate the effects of corrosion, you'll open up the cabinet and the metal flange underneath the gasket will literally be eaten away," says Butler.

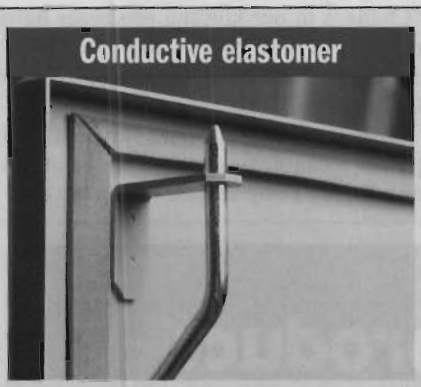
Form-in-place is one of the superstars of the conductive elastomer family. A silicone resin with conductive particles, the advantage of form-in-place is that it can be automatically applied by a robotic dispensing system. OEMs are particularly enthusiastic about the product, given that the only option before was to apply gaskets by hand. As a consequence, form-in-place is exceptionally popular in cell phones, telecommunications, and PC cards today. One limitation, however, precludes its use in large enclosures: Due to

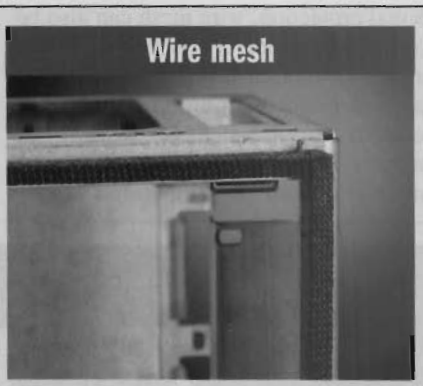
Seal of approval

If you decide your design needs EMI shielding, a metal (or metal-plated plastic) enclosure is the simplest way to accomplish this. The ideal enclosure would be one made out of a continuous piece of metal. In practice, enclosures have seams and other openings that are paths for electromagnetic waves. (A general rule of thumb for adequate shielding is no openings of more than 1/10 to 1/20 the wavelength of the highest frequency.)



Much like the gaskets on your refrigerator, EMI gaskets block these paths by providing a highly effective seal that keeps that pesky EMI out of trouble. For more details on EMI shielding and gaskets, Chomerics and Instrument Specialties have excellent tutorials in their catalogs. Contact information for both companies appears at the end of this article.





How EMI gaskets compare

Gasket type	Description	Shielding effectiveness[1]	Closure force requirements	Environmental protection?	Typical cost[2]	Ideal applications
Metal fingerstock	Linear rows of spring fingers (typically made from beryllium copper)	Very high	Low to high	No	$1-5.00/ft	Frequently opened door seams and other shear applications where low shear forces are required
Conductive elastomers	Elastomer with conductive fillers such as silver, carbon, silver-plated glass, silver-plated aluminum, silver-plated copper, and nickel-coated graphite	Moderate to very high	Low to high	Yes in co-extruded conductive/non-conductive foam	$1-5.00/ft	Indoor and outdoor shielded cabinets where environmental sealing is required
Form-in-place	Conductively filled elastomer compound, robotically dispensed onto programmed pathway or enclosure	Moderate to high	Moderate	Limited	$.05-.10/inch	Small enclosures with limited space for gaskets
Knitted conductive yarn, conductive fabric, or metal foil over form	Low closure, non-conductive foam lengths with conductive over-wrap	Moderate to high	Low to moderate	No	$1-2.00/ft	Indoor cabinets with moderate shielding requirements
Knitted wire mesh	All-metal wire cross section or wire over rubber core gaskets	Moderate to high	Low to high	No	Less than $1.00/ft	Enclosures with shielding requirements less than 1 GHz that are not frequently opened and closed
Wire mesh and elastomer combined	Wire mesh bonded along non-conductive elastomer gasket	Moderate	Moderate to high	Yes	$1-4.00/ft	Enclosures with shielding requirements less than 1 GHz

[1]The shielding effectiveness of gaskets varies widely; factors include the material type, size, and geometry of the gasket.

[2]Exact costs are extremely variable and will depend on the quantity of the gasket material required. Costs do not include installation, which can equal the cost of the gasket in some cases.

the tiny bead dispensed (0.034 inch high by 0.040 inch wide), the maximum flange width is about 0.1 cm.

As opposed to form-in-place, a *foam-in-place* conductive elastomer has been an elusive goal of enclosure makers. The strength of such a technology, they say, is that it would provide both EMI and environmental protection in a single gasket.

Cost reduction is the major driver, says Bob Lao, a senior designer at Hoffman Engineering (Anoka, MN), which sells about $890 million in enclosures annually. "EMC enclosures are a growing part of our business, and right now we have to install those EMI gaskets by hand, off-line. A foam-in-place product that we could dispense automatically would be a huge cost saver."

Unfortunately, the industry has to overcome major technical challenges in order to come up with a conductive foam-in-place product for practical use. "The question is how do you get the conductive properties you need, yet still retain all the properties of the foam and do it all in a liquid system?" says Paul Meyers, global product manager for foam-in-place products at H.B. Fuller (St. Paul, MN).

Wired. As the name implies, knitted wire mesh gaskets consist of all-metal wire strips knitted into rectangular or round cross sections. To provide environ-

mental protection, wire mesh can also be bonded along a non-conductive elastomer gasket. Low in cost, this type of gasket has had enduring popularity, in part because suppliers have worked to improve its resiliency through use of materials such as tin-plated steel. "Changes in our knitting processes have resulted in new gaskets that boast 80% deflection under low closure forces," says Chomerics' Butler.

Last but not least, a final option in EMI gasket technology consists of variations on a highly compressible foam core (typically urethane) with a conductive jacket, including knitted, silver-plated nylon yarn, knitted wire mesh, and fiberglass-reinforced foil. A major plus of these gaskets is their ability to provide both EMI and environmental protection. Helping spur sales is the relatively attractive trade-off in price, mechanical properties, and shielding effectiveness.

The developments in EMI gasket technology notwithstanding, Brewer, who consults with companies on EMC issues, urges engineers to think of the system as a whole. "Shielding may be the only suppression technique that can wholly stand alone, but you're going to have a hard time convincing somebody to buy something that looks like a U-Boat to put on their desktop," says Brewer.

The fact is that up to 40% of the total shielding budget for a system can be accounted for by reducing the amount of noise created by the electronics themselves. "You can take that right off the amount of shielding that is required," Brewer stresses.

Strategies for establishing EMC in a system include redesigning circuits, selecting devices that are less sensitive to interference, and the use of filters. Interestingly, Brewer is also seeing a growing trend among design engineers to use shielding not simply to meet regulations, but for functional and operational enhancement. "At the clock speeds we're seeing today, it's becoming necessary to protect areas of the circuitry from other areas," says Brewer.

Stay tuned to *Design News* for more on this trend and other EMC topics. dn

For more information

To speak with a company representative, call 1-800-828-6344, x 011 and key in the specific Product Code below or circle the number on the Reader Service Card:

EMI gaskets from Chomerics: Product Code 4475 or **Circle 549**

Foam-in-place gaskets from HB Fuller: Product Code 4476 or **Circle ...550**

EMC enclosures from Hoffman Engineering: Product Code 4478 or **Circle 551**

EMI gaskets from Instrument Specialties: Product Code 4477 or **Circle 552**

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